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April 10, 1998

U.S. Army Aviation & Missile Command
AMSMI-RD-WS-ST
ATTN: Mr. M. Bloemer
Redstone Arsenal, AL 35898

RE: Final Report
DAAH01-91-D-R005 D.O. 59

Dear Mr. Bloemer:

Please find enclosed a copy of the above noted **Final Report** for "Computational Characterization of Electromagnetic Field Propagation in Complex Structures" as required by the above referenced contract.

If you have any questions or need additional information, please contact me at (205) 890-6000 ext. 232.

Sincerely,

Andrea S. Dixon
Contract Assistant

ENC.

cc: AMSMI-AC-CR-BA/Sue Howard
ONRRR/Cynthia Sloan
DTIC
UAH/Fork
UAH/Accounting

UAH
The University of Alabama in Huntsville

Center for Applied Optics

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July 30, 1996

Dr. M. J. Bloemer
U.S. Missile Command
Weapons Science Directorate, AMSMI-RD-WS-ST
Research, Development, and Engineering Center,
Bldg. 7804, Room 242
Redstone Arsenal, Alabama 35898-5248 USA

Dear Dr. Bloemer,

Please accept the enclosed final report for the task "Computational characterization of electromagnetic field propagation in complex structures", DAAH01-91-D-ROOS D.O. 59. Dr. Michael Scalora performed the computational work and wrote the enclosed report. Our group performed experimental work on the optical delay line and found behavior that was in good agreement with the calculations.

As you know from your own involvement one result of this work was design of a structure that would permit electrical control of the optical delay in such structures. Our work on this topic indicated that electrical control of the optical delay is both feasible and desirable in making this technology into a practical device. We recommend as part of this report that such efforts should be carried out and would be glad to assist where appropriate and possible.

We have also more recently pursued the possibility of realizing structures that might provide such an adjustable optical delay capability using optically induced gratings in solid state structures. One interesting conclusion is that such gratings could be produced at very low excitation levels by utilizing optical microresonators in combination with excitonic resonances in short optical wavelength regimes.

Thank you for your role in making this work possible.

Best regards,

Richard L. Fork
Professor of Electrical and Computer Engineering

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Felicia Troupe
Print or Typed Name

205-890-6000
Telephone Number Ext

Felicia Troupe
Authorized Signature Date

Phone Call with Felicia Troupe (Joyce Chavas)

U.S. ARMY MISSILE COMMAND
Weapons Sciences Directorate, AMSMI-RD-WS-ST
Research, Development, and Engineering Center,
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Redstone Arsenal, Alabama 35898-5248 USA

Dr. Michael Scalora
Quantum Optics Group

Tel:(205)955-6955; Fax:(205)955-7216
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Final Report on "Computational characterization of electromagnetic field propagation in complex structures", DAAH01-91-D-ROOS D.O. 59.

The task was performed from 3/16/95 to 4/30/96. The focus of the research was the investigation of ultrashort pulse propagation in photonic band gap (PBG) structures. Most of the time was devoted to the development of a one-dimensional delay line made of semiconductor material. The result was the publication of the paper entitled "Ultrashort pulse propagation at the photonic band edge: large tunable group delay with minimal distprtion and loss", a copy of which has been attached to this report. This work is scheduled to appear for publication in the 1 August 1996 issue of Physical Review E. A patent disclosure baring the same title has also been filed jointly by MICOM and UAH.

Other activities were also carried out, some in support of the delay line work, that resulted in additional publications that have appeared, or are scheduled to appear. They are:

(1) M. Scalora, J.P. Dowling, A.S. Manka, C.M. Bowden, and J.W. Haus, *Pulse Propagation Near Highly Reflective Surfaces: Applications to Photonic Band Gap Structures andSuperluminal Tunneling Times,* Physical Review A **52**, 726 (1995).

(2) M. Tocci, M.J. Bloemer, M. Scalora, C.M. Bowden, and J.P. Dowling, *Spontaneous Emission and Nonlinear Effects in Photonic Band Gap Materials,* proceedings of the NATO Advanced Research Workshop: Quantum Optics in Wavelength-Scale Structures, Cargese, Corsica August 26-September 2 1995, edited by John Rarity (Plenum, NY, 1996).

(3) M. Tocci, M. Scalora, M.J. Bloemer, J.P. Dowling, and C.M. Bowden, *Measurement of spontaneous Emission rate near the band edge of a one-dimensional photonic band gap structure.* Physical Review A **53**, 2799, (1996).

(4) J. Bendickson, J.P. Dowling, and M. Scalora, *Analytic Expression for Mode-Density in Finite one Dimensional Structures.* Physiscal Review E **53**, 4107 (1996).

(5) A.S. Manka, M. Scalora, G. Kurizki, J.P. Dowling, and C.M. Bowden, *Optically Generated Photonic Band Gaps,* to appear in the Physical Review Letters.

Preliminary work also indicated that optical parametric oscillators for frequency up and down conversion should be feasible in one-dimensional PBG structures. Specifically, we predict at least three orders of magnitude increase in the power output from a micron size device when compared to its bulk counterpart. However, no suitable realistic material has been identified at this time because of the large material dispersion needed to achieve this conversion efficency.